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(54) CUBIC BORON NITRIDE SINTERED BODY AND CUTTING TOOL

(57) A sintered product contains cubic boron nitride; and a binder that includes at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIa element, a boride containing a Group VIII element and a Group

IVa, Group Va or Group VIa element, and an Al compound. The sintered product is improved in wear resistance and anti-falling property of cBN grains.

## Description

## Technical Field:

- 5 [0001] The present invention relates to a sintered product which is endowed with high hardness and excellent wear resistance and is useful as wear resistant material for fabricating cutting tools, bearings, wire-drawing dies, etc.

## Background Art:

- 10 [0002] Conventionally, tungsten carbide (WC)-based super-hard materials have been employed as wear resistant materials for fabricating cutting tools and similar tools. However, these WC-based super-hard materials encounter difficulty in satisfying users' demands, since the demands are becoming increasingly stringent. Thus, development of wear resistant materials of more excellent properties is desired.

- 15 [0003] Wear resistant materials that meet the above demands have already been proposed. For example, there have been proposed a sintered product of cubic boron nitride (hereinafter referred to as cBN) powder to which a metallic phase containing a small amount of Al and at least one alloying element selected from the group consisting of Ni, Co, Mn, Fe and V is incorporated (JP-A SHO 48-17503) and a cBN sintered product obtained by use of a ceramic binder (JP-B SHO 57-3631).

- 20 [0004] In recent years, performance of cutting machines has been remarkably enhanced, and cutting speed is prone to increase more and more so as to meet a demand for energy conservation. Thus, even when a cutting tool made of any of the aforementioned cBN sintered products is employed in high-speed cutting of, for example, cast iron, wear resistance of the tool deteriorates to thereby problematically shorten the service life thereof.

- 25 [0005] The cBN sintered products disclosed in the above JP-A SHO 48-17503 or JP-B SHO 57-3631 cannot attain sufficient wear resistance during cutting of cast iron under high-speed conditions. A conceivable reason for the former case is that the temperature of the cutting edge is elevated by cutting heat generated under high-speed cutting conditions and that although the heat causes cBN grains to be firmly retained in the sintered product to thereby promote densification of the product, reaction occurs between a material to be cut and a binder formed of an alloying element, such as Ni, Co, Fe, Mn or V, which is highly reactive with the material to be cut to thereby deteriorate wear resistance. In contrast, as in the latter case, when TiN or similar ceramic which is less reactive with a material to be cut and which has poor ability to retain cBN grains is employed as a binder, falling of cBN grains easily occurs. In addition, the cBN content generally cannot be increased to a high level due to difficulty in densification of the sintered product. Thus, sufficient wear resistance cannot be attained.

- 30 [0006] One object of the present invention is to provide a cBN sintered product low in reactivity with a material to be cut and excellent in wear resistance while maintaining excellent ability to maintain cBN grains therein.

- 35 [0007] Another object of the invention is to provide a cBN sintered product enhanced in thermal resistance and thermal conductivity of a binder and improved in wear resistance even in high-speed cutting of cast iron.

[0008] Still another object of the invention is to provide a cBN sintered product that can be cut by means of a wire-cut machine utilizing arc discharge, thereby attaining easy processability after sintering.

## 40 DISCLOSURE OF THE INVENTION:

[0009] The present invention provides a sintered product that contains cubic boron nitride; and a binder that comprises at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIa element, and a boride containing a Group VIII element and a Group IVa, Group Va or Group VIa element.

- 45 [0010] In the sintered product, the binder can comprise at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIa element; a boride containing a Group VIII element and a Group IVa, Group Va or Group VIa element; and an Al compound.

[0011] In the sintered product, the nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIa element are TiN, TiC,  $TiC_xN_{1-x}$  ( $0 < x < 1$ ), TiB<sub>2</sub>, WC, WB and W<sub>2</sub>B.

- 50 [0012] In the sintered product, the boride containing a Group VIII element and a Group IVa, Group Va or Group VIa element is WCoB, W<sub>2</sub>CO<sub>2</sub>B<sub>3</sub>, W<sub>3</sub>COB<sub>2</sub> or W<sub>2</sub>COB<sub>2</sub>.

[0013] In the sintered product, the Al compound is AlN or AlB<sub>2</sub>.

- 55 [0014] In the sintered product, the cubic boron nitride is in an amount falling within a range of 50 to 95 area %; and the binder contains the at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIa element in an amount falling within a range of 58 to 98 area % and the boride containing a Group VIII element and a Group IVa, Group Va or Group VIa element in an amount falling within a range of 2 to 42 area %, each based on a total amount of the binder.

[0015] In the sintered product, the cubic boron nitride is in an amount falling within a range of 50 to 95 area %; and

the binder contains the at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element in an amount falling within a range of 36 to 78 area %, the boride containing a Group VIII element and a Group IVa, Group Va or Group Via element in an amount falling within a range of 2 to 43 area % and the Al compound in an amount falling within a range of 16 to 33 area %, each based on a total amount of the binder.

**[0016]** The present invention further provides a cutting tool employing any one of the sintered products described above.

**[0017]** As described in the foregoing, there can be obtained a cBN sintered product low in reactivity with a material to be cut and excellent in wear resistance while maintaining excellent ability to retain cBN grains therein, when containing at least two compounds, one being at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element, and the other being a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element.

#### Best Mode for Carrying out the Invention:

**[0018]** The present inventors have made earnest studies to obtain a cBN sintered product excellent in wear resistance, and have found that a cBN sintered product can attain excellent wear resistance, lower reactivity with a material to be cut while maintaining excellent ability to retain cBN grains therein, when containing, as a binder, at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via, and a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element; or when containing, as a binder, at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element, a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element, and an Al compound. The inventors have also found that heat resistance and thermal conductivity of the aforementioned binder can be enhanced to thereby synergistically further improve wear resistance of a cutting tip of a tool that is subjected to high temperature conditions during high-speed cutting. The inventors have also found that the sintered product can be cut by means of a wire-cut machine utilizing arc discharge, thereby attaining easy processability after sintering. The present invention has been accomplished on the basis of these findings.

**[0019]** Examples of nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element, serving as binder components incorporated in the sintered product of the present invention include TiC, TiB<sub>2</sub>, Ti<sub>3</sub>B<sub>4</sub>, TiB, TiN, Ti<sub>2</sub>N, TiC<sub>x</sub>N<sub>1-x</sub> (0<x<1), ZrC, ZrB<sub>2</sub>, ZrB<sub>12</sub>, ZrN, ZrC<sub>x</sub>N<sub>1-x</sub> (0<x<1), HfC, HfB<sub>2</sub>, HfB, HfB<sub>12</sub>, Hf<sub>3</sub>N<sub>2</sub>, HfN, Hf<sub>2</sub>N<sub>3</sub>, HfC<sub>x</sub>N<sub>1-x</sub> (0<x<1), VC, V<sub>4</sub>C<sub>3</sub>, V<sub>6</sub>C<sub>7</sub>, VB<sub>2</sub>, V<sub>3</sub>B<sub>4</sub>, V<sub>5</sub>B<sub>12</sub>, VB, V<sub>2</sub>B<sub>3</sub>, V<sub>2</sub>B<sub>2</sub>, VN, V<sub>2</sub>N, VC<sub>x</sub>N<sub>1-x</sub> (0<x<1), NbC, Nb<sub>2</sub>C<sub>3</sub>, Nb<sub>2</sub>C, NbB<sub>2</sub>, Nb<sub>2</sub>B<sub>2</sub>, NbB, NbN, Nb<sub>4</sub>N<sub>3</sub>, Nb<sub>2</sub>N, NbC<sub>x</sub>N<sub>1-x</sub> (0<x<1), TaC, Ta<sub>2</sub>C, TaB<sub>2</sub>, Ta<sub>3</sub>B<sub>2</sub>, Ta<sub>3</sub>B<sub>4</sub>, TaB, Ta<sub>3</sub>B<sub>4</sub>, TaN, Ta<sub>3</sub>N<sub>3</sub>, Ta<sub>4</sub>N, Ta<sub>2</sub>N, TaC<sub>x</sub>N<sub>1-x</sub> (0<x<1), Cr<sub>3</sub>C<sub>2</sub>, Cr<sub>2</sub>C, Cr<sub>23</sub>C<sub>8</sub>, Cr<sub>7</sub>C<sub>3</sub>, CrB, CrB<sub>4</sub>, Cr<sub>2</sub>B, Cr<sub>2</sub>B<sub>3</sub>, Cr<sub>5</sub>B<sub>3</sub>, CrB<sub>2</sub>, Cr<sub>2</sub>N, CrN, Mo<sub>2</sub>C, MoC, MoB, Mo<sub>2</sub>B<sub>5</sub>, MoB<sub>3</sub>, Mo<sub>2</sub>B, MoB<sub>2</sub>, WC, W<sub>2</sub>C, WB, W<sub>2</sub>B, WB<sub>3</sub>, WN, W<sub>2</sub>N, a solid solution thereof, a multi-component compound thereof and a compound thereof having an unspecified composition. Of these, TiN, TiC, TiC<sub>x</sub>N<sub>1-x</sub> (0<x<1), TiB<sub>2</sub>, WC, WB and W<sub>2</sub>B are particularly preferred.

**[0020]** The boride containing a Group VIII element and a Group IVa, Group Va or Group Via element refers to a compound represented by M<sub>1</sub><sub>x</sub>M<sub>2</sub><sub>y</sub>B<sub>z</sub> (M<sub>1</sub>: Group IVa, Group Va or Group Via element; M<sub>2</sub>: Group VIII element; x, y, z>0) and including a solid solution thereof and a compound thereof having an unspecified composition. Examples thereof include W<sub>2</sub>FeB, WFeB, MoFe<sub>2</sub>B<sub>4</sub>, Mo<sub>2</sub>Fe<sub>13</sub>B<sub>5</sub>, MoFe<sub>2</sub>B<sub>4</sub>, Mo<sub>2</sub>FeB<sub>2</sub>, TaN<sub>2</sub>, HfCO<sub>3</sub>B<sub>2</sub>, MoCoB, Mo<sub>2</sub>CoB<sub>2</sub>, MoCo<sub>2</sub>B<sub>4</sub>, NbCoB<sub>2</sub>, NbCoB, Nb<sub>3</sub>CO<sub>3</sub>B<sub>7</sub>, Nb<sub>2</sub>CO<sub>3</sub>B<sub>3</sub>, W<sub>3</sub>COB<sub>3</sub>, WCoB, W<sub>2</sub>Co<sub>2</sub>B<sub>2</sub> and W<sub>2</sub>CO<sub>2</sub>B<sub>8</sub>. Of these, WCoB, W<sub>2</sub>Co<sub>2</sub>B<sub>8</sub>, W<sub>3</sub>CoB<sub>3</sub> and W<sub>2</sub>CoB<sub>2</sub> are particularly preferred.

**[0021]** Examples of the Al compound include AlB<sub>12</sub>, AlB<sub>10</sub>, AlB<sub>2</sub>, Al<sub>3</sub>B<sub>48</sub>C<sub>2</sub>, Al<sub>3</sub>B<sub>6</sub>C<sub>7</sub>, AlB<sub>12</sub>C<sub>2</sub> and AlN. Of these, AlN and AlB<sub>2</sub> are particularly preferred.

**[0022]** When a nitride, carbide, carbide nitride and/or boride of a Group IVa, Group Va or Group Via element is incorporated into a binder for producing a cBN sintered product, reactivity of the sintered product with a material to be cut can be reduced, and hardness of the binder itself can be increased. When a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element is incorporated into a binder for producing a cBN sintered product, mechanical strength and toughness of the sintered product can be increased; densification of the sintered product can be enhanced; reactivity of the sintered product with a material to be cut can be reduced; and wear resistance under high-speed cutting conditions can be increased. When an Al compound is added to the binder, heat resistance, thermal conductivity, etc. of the binder can be enhanced to thereby further improve characteristics of the cBN sintered product.

**[0023]** The sintered product of the present invention contains cBN preferably in an amount of 50 to 95 area %, more preferably 55 to 95 area %, most preferably 80 to 95 area %, and the balance being preferably a binder.

**[0024]** The term "area %" used herein refers to a percent area of a relevant component contained in a composition observed on a polished surface of a portion of the sintered product. Although the area % may be determined by means of a metallographical microscope or a similar apparatus, the cBN content and the crystal composition of a binder is generally measured by means of an X-ray diffraction apparatus, an electron beam microanalyzer or a graphic image

analyzer.

[0025] When the cBN content is less than 50 area %, hardness and thermal conductivity sufficient for use in high-speed cutting cannot be attained, whereas when the cBN content is in excess of 95%, attaining densification of the sintered product disadvantageously requires high sintering temperature and pressure. The cBN powder to be used suitably has an average particle size falling within a range of 6 to 0.1  $\mu\text{m}$ , preferably 3 to 0.1  $\mu\text{m}$ .

[0026] The binder contains species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element preferably in an amount falling within a range of 58 to 98 area %, more preferably 65 to 98 area %, most preferably 74 to 98 area %; and a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element in an amount falling within a range of 2 to 42 area %, more preferably 2 to 35 area %, most preferably 2 to 26 area %, each based on the total amount of the binder.

[0027] In the case where the binder contains an AT compound, the binder contains species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element preferably in an amount falling within a range of 36 to 78 area %, more preferably 40 to 75 area %, most preferably 50 to 70 area %; a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element preferably in an amount falling within a range of 2 to 43 area %, more preferably 2 to 39 area %, most preferably 2 to 35 area %; and an Al compound preferably in an amount falling within a range of 16 to 33 area %, more preferably 20 to 33 area %, most preferably 25 to 33 area %.

[0028] In the case where the binder contains no Al compound, when at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element is contained in an amount less than 58%, effects on reduction of reactivity with a material to be cut and on enhancement of hardness of the binder are insufficient, whereas when the amount is in excess of 98%, toughness of the sintered product is lowered. In addition, when the boride containing a Group VIII element and a Group IVa, Group Va or Group Via element is contained in an amount less than 2%, effects on enhancement of mechanical strength and toughness of the sintered product are insufficient, whereas when the amount is in excess of 42%, hardness of the sintered product decreases.

These are not preferred.

[0029] In the case where the binder contains an Al compound, when at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element is contained in an amount less than 36%, effects on reduction of reactivity with a material to be cut and on enhancement of hardness of the binder are insufficient, whereas when the amount is in excess of 78%, toughness of the sintered product is lowered.

In addition, when the boride containing a Group VIII element and a Group IVa, Group Va or Group Via element is contained in an amount less than 2%, effects on enhancement of mechanical strength and toughness of the sintered product are insufficient, whereas when the amount is in excess of 43%, hardness of the sintered product is lowered. When the Al compound content is less than 16%, effects on enhancement of heat resistance and thermal conductivity of the binder are insufficient, whereas when the content is in excess of 33%, hardness of the sintered product is lowered.

These are not preferred.

[0030] In order to obtain the sintered product of the present invention, the following procedure may be followed. Specifically, powder of at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group Via element and powder of a boride containing a Group VIII element and a Group IVa, Group Va or Group Via element are mixed together. Powder of an optional Al compound can be added to the mixture.

The resultant mixture is heated in accordance with needs, or is not subjected to heat treatment, and sintered under ultrahigh pressure at high temperature. The sintered product of the present invention can also be produced by use of any combination of powders other than those employed in the above case. In other words, any combination may be employed so long as the cBN sintered product of the present invention containing a binder of a composition and area % falling within a range of the present invention can be produced through heat treatment of the powder mixture and sintering under high pressure.

[0031] For example, in the case in which another combination of powders is employed, starting material powders may be of element metals of Group IVa, Group Va, Group Via, or Group VIII; Al; alloys thereof; intermetallic compounds thereof; boron, carbon, boron carbide, and boron nitride; carbides, nitrides, carbide nitrides, borides, boride nitrides, and boride carbides of Al, those of a Group IVa, Group Va, or Group Via element, and those of a Group VIII element; a multi-component compound thereof; solid solution thereof; or a compound having an unspecified composition. These powders are mixed together, and the resultant mixture is heated in accordance with needs, or is not subject to heat treatment, and sintered under ultrahigh pressure at high temperature. In this case, cBN powder can serve as a nitrogen source or a boron source for forming a binder.

[0032] During production of the sintered product of the present invention, heat treatment is performed preferably in a vacuum or a non-oxidizing atmosphere of, for example,  $\text{N}_2$  or Ar. In addition, in order to produce the product of the present invention, a pressure of 4.5 GPa or higher and a temperature of 1,400°C or higher are preferably employed. Sintering must be performed under conditions in which cBN remains stable. If sintering temperature is lower than 1,400°C, obtaining the sintered product of the present invention requires a long period of time. Also, in a production

method in which a binder of interest is generated through heating, such a low temperature may lead to insufficient generation of the target binder. Thus, in some cases, residues, such as metallic Co, generate to thereby deteriorate wear resistance of the sintered product.

[0033] The sintered product thus obtained is cut off by means of a wire-cut machine utilizing arc discharge to form a wear resistant cutting tool.

[0034] Though Examples of the present invention will be described below, the invention is not limited to these Examples.

Examples 1 to 15 and Comparative Examples 1 to 8:

[0035] As shown in Table 1, cBN powder (average particle size: 1  $\mu\text{m}$ ) and binder components were weighed and mixed to yield raw material powders, and each powder was wet-kneaded for 24 hours by use of a ball mill to thereby yield slurry. Acetone (special grade chemical) was used as a solvent for mixing. The slurry was sufficiently dried, and subsequently, the dried matter was introduced into an ultrahigh-pressure sintering apparatus and sintered for one hour under the conditions shown in Table 1 to thereby yield a sintered product (diameter: 29 mm, thickness: 5 mm). The top and bottom surfaces of the sintered product were ground with diamond wheel stone.

Table 1 (1/3)

	Components and compositional proportions (wt.%)	CBN content (area %)	Sintering temp. (°C)	Crystal composition (proportions) of binder					Width of flank wear (mm)
				(1)	(2)	(3)	Area % of (1)	Area % of (2)	Area % of (3)
Ex. 1	cBN(87), Ti <sub>3</sub> AlN(8), WC-Co(5)	90	1,500	TiN, TiB <sub>2</sub> , WC	WCoB, WCo <sub>2</sub> B <sub>6</sub> , AlB <sub>3</sub>	AlN, AlB <sub>3</sub>	40	39	21
Ex. 2	cBN(85), Ti <sub>3</sub> AlN(11), WC-Co(5)	85	1,500	TiN, TiB <sub>2</sub> , WC	WCoB, WCo <sub>2</sub> B <sub>6</sub>	AlN	55	25	20
Ex. 3	cBN(85), TiN(5), WC-Co(10)	85	1,500	TiN, TiB <sub>2</sub> , WC	WCoB, WCo <sub>2</sub> B <sub>6</sub>	-	74	26	-
Ex. 4	cBN(85), Ti <sub>3</sub> AlN(15), WC-Co(10)	80	1,500	TiN, TiB <sub>2</sub> , WB	WCoB <sub>2</sub>	AlN, AlB <sub>3</sub>	64	8	28
Ex. 5	cBN(85), TiN(5), TiC(5), WC-Co(15)	80	1,500	TiN, TiC, TiB <sub>2</sub> , WB	WCoB	-	89	11	-
Ex. 6	cBN(74), Ti <sub>3</sub> AlN(21), WC-Co(5)	76	1,500	TiN, TiB <sub>2</sub> , WC, WB	WCoB <sub>2</sub>	AlN	66	3	31
Ex. 7	cBN(74), TiN(21), WC-Co(5)	75	1,500	TiN, TiB <sub>2</sub> , WC, WB	WCoB <sub>2</sub>	-	95	5	-

(1) Group IVa, Va and VIA compounds

(2) Group IVa, Va and VIA compounds &amp; Group VIII borides

(3) Al compounds

Table 1 (2/3)

	Components and compositional proportions (wt. %)	cBN content (area %)	Sintering temp. (°C)	Crystal composition (proportions) of binder					Width of flank wear (mm)
				(1)	(2)	(3)	Area % of (1)	Area % of (2)	Area % of (3)
Ex. 8	cBN (66), Ti <sub>3</sub> AlN (20), TiC (4), WC-Co (10)	70	1,500	TiN, TiC, TiB <sub>2</sub> , WC, WB	W <sub>2</sub> CoB <sub>2</sub>	AlN, AlB <sub>2</sub>	64	6	30
Ex. 9	cBN (66), TiN (12), TiC (12), WC-Co (10)	70	1,500	TiN, TiC, TiB <sub>2</sub> , WC, WB	W <sub>2</sub> CoB <sub>2</sub>	-	91	9	-
Ex. 10	cBN (65), TaN (10), TiN (10), Al (5), WC-Co (10)	65	1,500	TiN, TaN, TiB <sub>2</sub> , WC	W <sub>2</sub> CoB <sub>2</sub>	AlN, AlB <sub>2</sub>	64	8	28
Ex. 11	cBN (65), TaN (10), TiN (20), WC-Co (5)	65	1,500	TiN, TaN, TiB <sub>2</sub> , WC	W <sub>2</sub> CoB <sub>2</sub>	-	95	5	-
Ex. 12	cBN (64), Ti <sub>3</sub> AlN (32), WC-Co (4)	64	1,500	TiN, TiB <sub>2</sub>	W <sub>2</sub> CoB <sub>2</sub>	AlN	65	4	31
Ex. 13	cBN (54), TiN (15), TiC (20), Al (8), WC-Co (5)	50	1,500	TiC, TiN, TiB <sub>2</sub> , W <sub>2</sub> B	W <sub>2</sub> CoB <sub>2</sub>	AlN, AlB <sub>2</sub>	63	5	32
Ex. 14	cBN (54), TiN (20), TiC (23), WC-Co (5)	50	1,500	TiC, TiN, TiB <sub>2</sub> , W <sub>2</sub> B	W <sub>2</sub> CoB <sub>2</sub>	-	98	2	-
Ex. 15	cBN (54), Ti <sub>3</sub> AlN (43), WC-Co (3)	50	1,500	TiN, TiB <sub>2</sub> , WC, W <sub>2</sub> B	W <sub>2</sub> CoB <sub>2</sub>	AlN	66	2	32

(1) Group IVa, Va and VIA compounds

(2) Group IVa, Va and VIA compounds &amp; Group VIII borides

(3) Al compounds

Table 1 (3/3)

	Components and compositional proportions (wt %)	cBN content (area %)	Sintering temp. (°C)	Crystal composition (proportions) of binder				Width of flank wear (mm)	
				(1)	(2)	(3)	Area % of (1)		Area % of (2)
Comp. Ex. 1	cBN(90), Al(5), WC-Co(5)	90	1,500	-	WCoB, WCoB <sub>2</sub>	AlN, AlB <sub>2</sub>	-	50	Life end 6,000 m.
Comp. Ex. 2	cBN(84), TiN(5), TiC(5), Al(6)	90	1,200	TiN, TiC, TiB <sub>2</sub>	-	AlN, AlB <sub>2</sub>	32	-	Life end 2,000 m
Comp. Ex. 3	cBN(80), TiC(10), Al(10)	85	1,200	TiC, TiB <sub>2</sub>	-	AlN, AlB <sub>2</sub>	23	-	Life end 2,500 m
Comp. Ex. 4	cBN(74), TiAl <sub>3</sub> (21), WC(5)	80	1,200	TiN, TiB <sub>2</sub> , WC	-	AlN, AlB <sub>2</sub>	34	-	Life end 2,000 m
Comp. Ex. 5	cBN(61), TiC(18), Al(16), WC(5)	70	1,200	TiC, TiB <sub>2</sub> , WC	-	AlN, AlB <sub>2</sub>	26	-	Life end 2,000 m.
Comp. Ex. 6	cBN(58), TiCN(22), Al(15), WC(5)	70	1,200	TiCN, TiB <sub>2</sub> , WC	-	AlN, AlB <sub>2</sub>	30	-	Life end 3,000 m
Comp. Ex. 7	cBN(45), TiN(42), Al(13)	60	1,200	TiN, TiB <sub>2</sub>	-	AlN, AlB <sub>2</sub>	45	-	Life end 2,500 m
Comp. Ex. 8	cBN(35), TiC(48), Al(13), WC(5)	50	1,200	TiC, TiB <sub>2</sub>	-	AlN, AlB <sub>2</sub>	51	-	Life end 3,000 m.

(1) Group IVa, Va and VIA compounds

(2) Group IVa, Va and VIA compounds &amp; Group VIII borides

(3) Al compounds



[0036] The sintered product was cut into tips (13 mm × 13 mm) by means of a wire-cut machine utilizing arc discharge, and each tip was processed into a cutting tool of the shape specified by JIS/SNMM120308.

[0037] The tool was evaluated in terms of wear resistance and the anti-falling property of cBN grains (i.e., chipping resistance of cutting edge) through a dry high-speed cutting test by turning. The cutting test was performed under the following conditions: material to be cut = FC 250; cutting speed = 650 m/min; depth of cut = 2.0 mm; feed per revolution = 0.3 mm/revolution; and cutting length = 10,000 m.

[0038] After completion of the cutting test, the width of flank wear of the tested cutting edge sample was measured. In addition, a portion of the sample was polished, and the polished surface was analyzed by means of an X-ray diffraction apparatus, an electron beam microanalyzer and a graphic image analyzer to thereby determine the cBN content and the crystal composition of the binder. Table 1 shows the results. When the width of the flank wear of the cutting edge reached 0.3 mm, the end of tool life (service life) was judged to have reached, and the test was terminated.

[0039] As is clear from Table 1, the sintered product of the present invention exhibits a small width of flank wear as compared with similar conventional sintered products, and high wear resistance and anti-falling property of cBN grains can be attained.

#### Industrial Applicability:

[0040] The sintered cBN product of the present invention attains excellent wear resistance and anti-falling property of cBN grains as compared with similar conventional sintered products, even when the product is used under severe working conditions. Particularly, when the sintered product is used as a cutting tip, there can be attained excellent cutting performance; e.g., reduced width of flank wear, as compared with conventional cBN sintered product tips. Thus, the frequency of replace of tips during cutting or lathe turning can be reduced to thereby attain high productivity.

#### Claims

1. A sintered product that contains cubic boron nitride; and a binder that comprises at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIA element, and a boride containing a Group VIII element and a Group IVa, Group Va or Group VIA element.
2. The sintered product according to claim 1, wherein the binder comprises at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIA element; a boride containing a Group VIII element and a Group IVa, Group Va or Group VIA element; and an Al compound.
3. The sintered product according to claim 1 or claim 2, wherein the nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIA element are TiN, TiC,  $TiC_xN_{1-x}$  ( $0 < x < 1$ ),  $TiB_2$ , WC, WB and  $W_2B_6$ .
4. The sintered product according to any one of claims 1 to 3, wherein the boride containing a Group VIII element and a Group IVa, Group Va or Group VIA element is  $WCoB$ ,  $W_2Co_{21}B_6$ ,  $W_3CoB_3$  or  $W_2CoB_2$ .
5. The sintered product according to any one of claims 2 to 4, wherein the Al compound is AlN or  $AlB_2$ .
6. The sintered product according to any one of claims 1 to 5, wherein the cubic boron nitride is in an amount falling within a range of 50 to 95 area %; and the binder contains the at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIA element in an amount falling within a range of 58 to 98 area % and the boride containing a Group VIII element and a Group IVa, Group Va or Group VIA element in an amount falling within a range of 2 to 42 area %, each based on a total amount of the binder.
7. The sintered product according to any one of claims 2 to 6, wherein the cubic boron nitride is in an amount falling within a range of 50 to 95 area %; and the binder contains the at least one species selected from among nitrides, carbides, carbide nitrides and borides of a Group IVa, Group Va or Group VIA element in an amount falling within a range of 36 to 78 area %, the boride containing a Group VIII element and a Group IVa, Group Va or Group VIA element in an amount falling within a range of 2 to 43 area % and the Al compound in an amount falling within a range of 16 to 33 area %, each based on a total amount of the binder.
8. A cutting tool employing the sintered product according to any one of claims 1 to 7.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP02/00697

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. <sup>7</sup> C04B35/5831		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. Cl. <sup>7</sup> C04B35/5831		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926-2002 Toroku Jitsuyo Shinan Koho 1994-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Jitsuyo Shinan Toroku Koho 1996-2002		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 974566 A1 (SUMITOMO ELECTRIC INDUSTRIES, LTD.), 26 January, 2000 (26.01.2000), Claims; Table 7, No. 42, No. 44; Table 8, No. 50, No. 52, [0001] & JP 2000-44350 A	1-7 8
X	Claims; Table 4, No. 23, No. 25; Par. No. [0001]	
X	JP 8-34669 A (Kyocera Corporation), 06 February, 1996 (06.02.1996), Claim 2	1-7 8
X	Par. No. [0001] (Family: none)	
A	JP 8-91936 A (Kyocera Corporation), 09 April, 1996 (09.04.1996), Claims; Par. No. [0001] (Family: none)	1-8
A	JP 63-175367 A (Mitsubishi Metal Corporation), 20 July, 1988 (20.07.1988), Claims (Family: none)	1-8
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document: but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family	
Date of the actual completion of the international search 15 February, 2002 (15.02.02)		Date of mailing of the international search report 26 February, 2002 (26.02.02)
Name and mailing address of the ISA/ Japanese Patent Office  Facsimile No.		Authorized officer  Telephone No.

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